PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:   10/789,540

Filing Date: February 27, 2004

Applicant: Eric Sandstrom

Group Art Unit: 3609

Examiner: Nicholas Kiswanto

Title: CONCEPT FOR USING SOFTWARE / ELECTRONICS TO CALIBRATE THE CONTROL SYSTEM FOR AN AUTOMATIC TRANSMISSION

Attorney Docket: DKT03066A (BWI-00084)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Supplemental Declaration Under Rule 131(a)

Dear Sir:

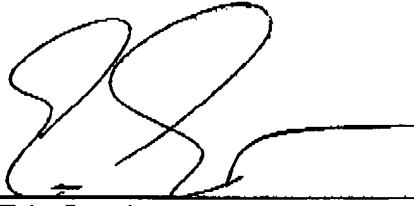Eric Sandstrom, the applicant in the above-identified patent application declares as follows:

1.   That on or prior to November 4, 2002, I conceived a method of calibrating a unique proportional selonoid of a unique member of a predesigned class of electrohydraulic control systems that is inclusive of at least one valve controlled by a proportional solenoid that provides an output response in response to an input current, said method comprising   identifying a characteristic equation of the proportional solenoid in the electrohydraulic system, said characteristic equation including a plurality of coefficients; imbedding into a control unit for the electrohydraulic control system the characteristic equation; coupling the electrohydraulic system to a test stand; applying a

plurality of different currents to the unique solenoid of the electrohydraulic system; measuring the output response of the unique electrohydraulic system for each of the plurality of currents; identifying the unique coefficients in the characteristic equation from the output response measurements, and flashing the coefficients in a memory of the control unit of the apparatus utilized with such above noted method be shown and described in the accompanying Exhibit A including a front page, and a signature page along with a witnessing page along with additional attached pages .

2.   Applicant has diligently pursued such inventive method from a date of conception on or prior to November 4, 2002 until a subsequent continuous reduction to practice filing of a provisional patent application on April 11, 2003 and a further filing of a nonprovisional application claiming the benefit of the provisional application filed on February 27, 2004 evidence (Exhibit B) of such diligence is showm and demonstrated in a copy of an e-mail sent to Johannes Braum of Volkswagon, Germany wherein coefficient data regarding the invention show in Exhibit A is given and by an accompanying Exhibit C of coefficient data regarding the invention derived on March 19, 2003.

The declarant further states that the above statements were made with the knowledge that willful false statements and the like are punishable by fine and/or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that any such willful false statement may jeopardize the validity of this application or any patent resulting therefrom.
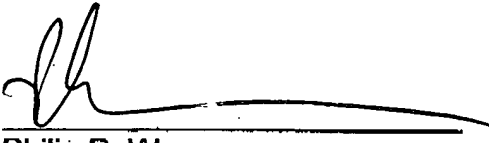
Date: 3/31/08

Eric Sandstrom

P.O. Box 70098
Rochester Hills, MI 48326
(248) 364-4300

Respectfully submitted,

WARN PARTNERS, P.C.
Attorneys for Applicant

Dated: March 31, 2008

By: _____
Philip R. Warn
Reg. No. 32775

PRW:EEH:mlb

EXHIBIT A

VW Clutch Pressure Calibration
E.C.Sandstrom

Characteristic Equation: $i(P) = c1 + \dfrac{c2}{1 + P} + c3 \cdot P + c4 \cdot P^2 + \dfrac{c5}{P^3 + 0.0001}$

Sample Equation with Coefficients:

$$i(P) := 0.376 - \frac{242}{1 + P} + 0.059 \cdot P + 1.681 \cdot 10^{-5} \cdot P^2 - \frac{7.328 \cdot 10^{-9}}{P^3 + 0.0001}$$

VW Clutch Current vs. Pressure

— Fit
— Actual
— Actual + 1%
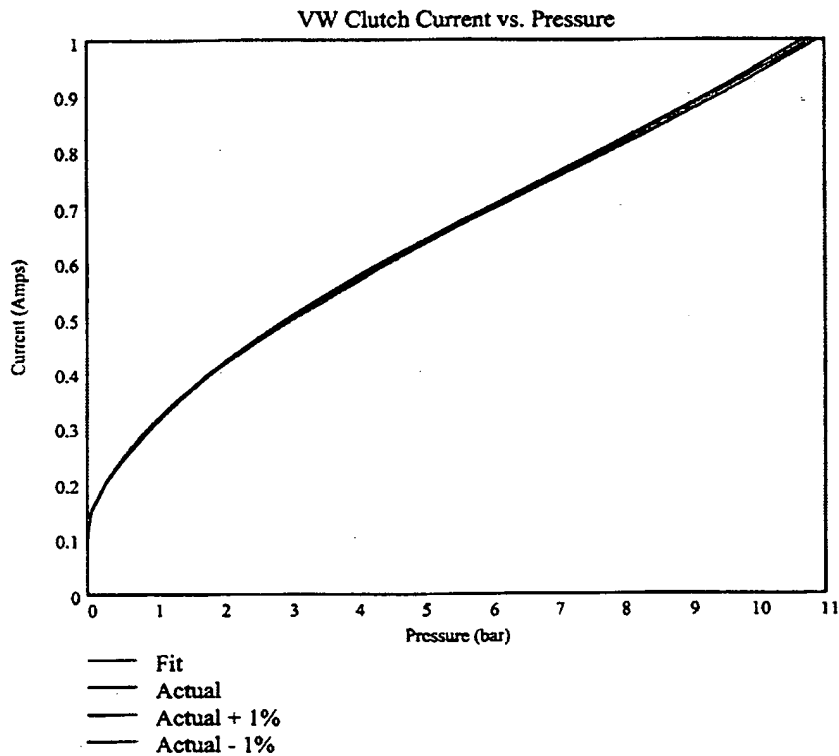— Actual - 1%

clutch.mcd

11/4/2002

VW Clutch Pressure Calibration
E.C.Sandstrom

Characteristic Equation:
$$i(P) = c1 + \frac{c2}{1 + P} + c3 \cdot P + c4 \cdot P^2 + \frac{c5}{P^3 + 0.0001}$$

Sample Equation with Coefficients:

$$i(P) := 0.376 - \frac{.242}{1 + P} + 0.059 \cdot P + 1.681 \cdot 10^{-5} \cdot P^2 - \frac{7.328 \cdot 10^{-9}}{P^3 + 0.0001}$$
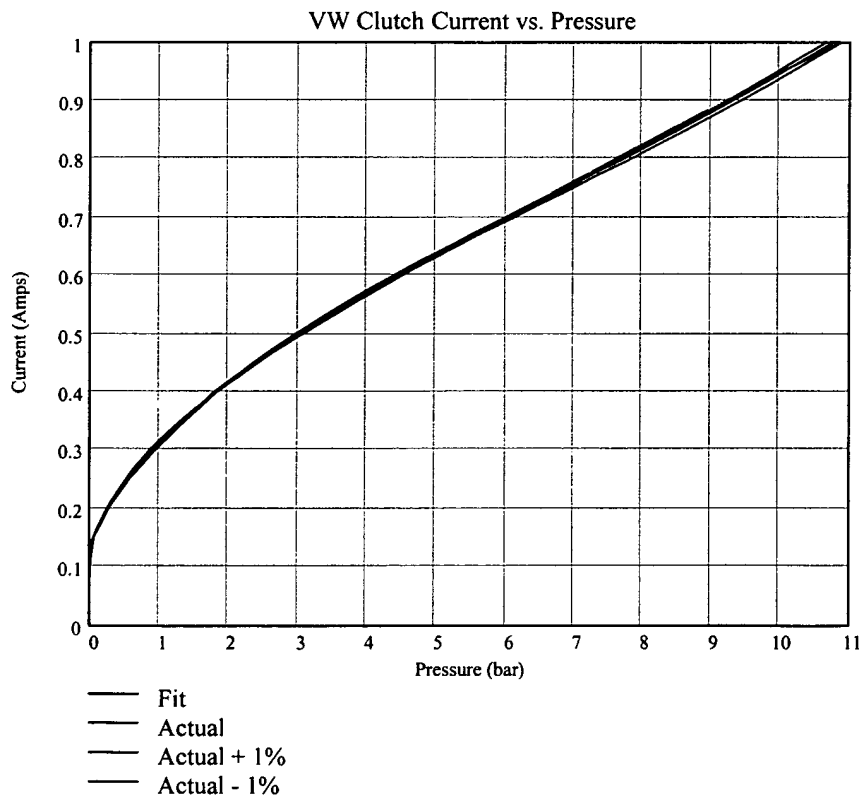
VW Clutch Current vs. Pressure

Current (Amps) vs. Pressure (bar)

— Fit
— Actual
— Actual + 1%
— Actual - 1%

clutch.mcd

VW Lube Flow Calibration
E.C.Sandstrom

Characteristic Equation:
$$i(Q) = c1 + c2 \cdot \left(Q^2 \cdot K\right) + \frac{c3}{1 + Q^2 \cdot K} + c4 \cdot e^{Q^2 \cdot K}$$

Sample Equation with Coefficients:

$$i(Q) := 0.834 - 0.061 \cdot \left(Q^2 \cdot K\right) + \frac{0.123}{1 + Q^2 \cdot K} - 4.958 \cdot 10^{-4} \cdot e^{Q^2 \cdot K}$$

where; $K = 0.017$

VW Lube Current vs. Lube Flow

—— Fit
—— Actual

lube.mcd
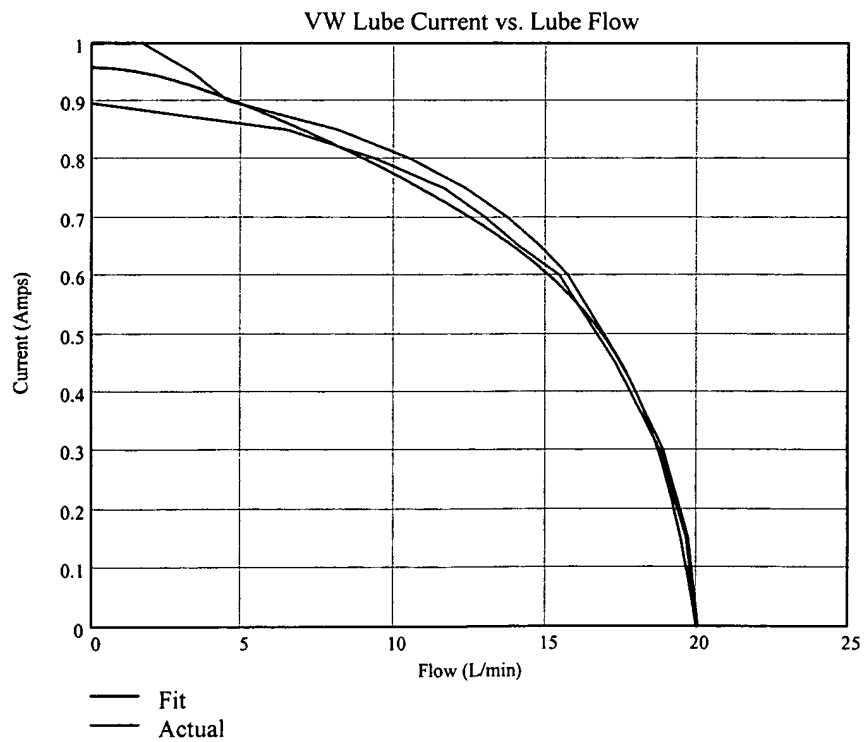
VW Line Pressure Calibration (20 bar)
E.C.Sandstrom

Characteristic Equation: $\quad i(P) = c1 + c2 \cdot P + c3 \cdot P^2 + c4 \cdot e^P$

Sample Equation with Coefficients:

$$i(P) := 1.082 - 0.032 \cdot P + -4.906 \cdot 10^{-4} \cdot P^2 - 4.231 \cdot 10^{-10} \cdot e^P$$

Line Current vs. Line Pressure

—— Fit
—— Actual

lp_20.mcd
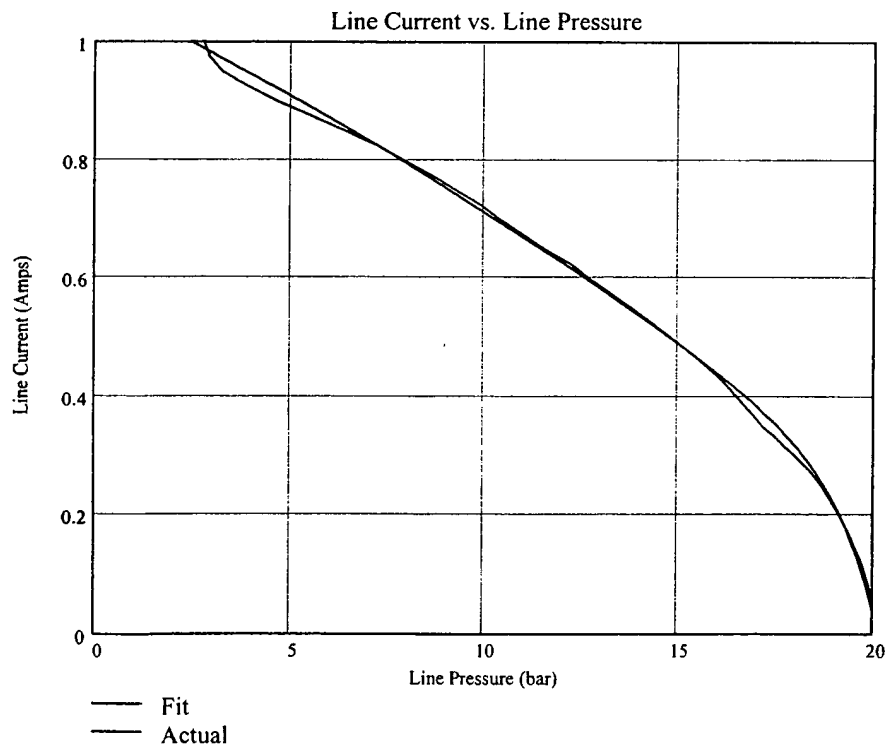
VW Cut-off Valve Calibration
E.C.Sandstrom

Characteristic Equation: $\quad i(P) = c1 + \dfrac{c2}{1+P} + c3 \cdot x + \dfrac{c4}{0.0001 + P^3} + c5 \cdot x^2$

Sample Equation with Coefficients:

$$i(P) := 0.426 - \frac{0.15}{1+P} + 0.017 \cdot P - \frac{1.768 \cdot 10^{-5}}{0.0001 + P^3} + 6.033 \cdot 10^{-4} \cdot P^2$$

Safety Current vs. Safety Pressure

——— Fit
——— Actual-PREDICTED

safety.mcd

DCS System Technology

Mechatronics Technology
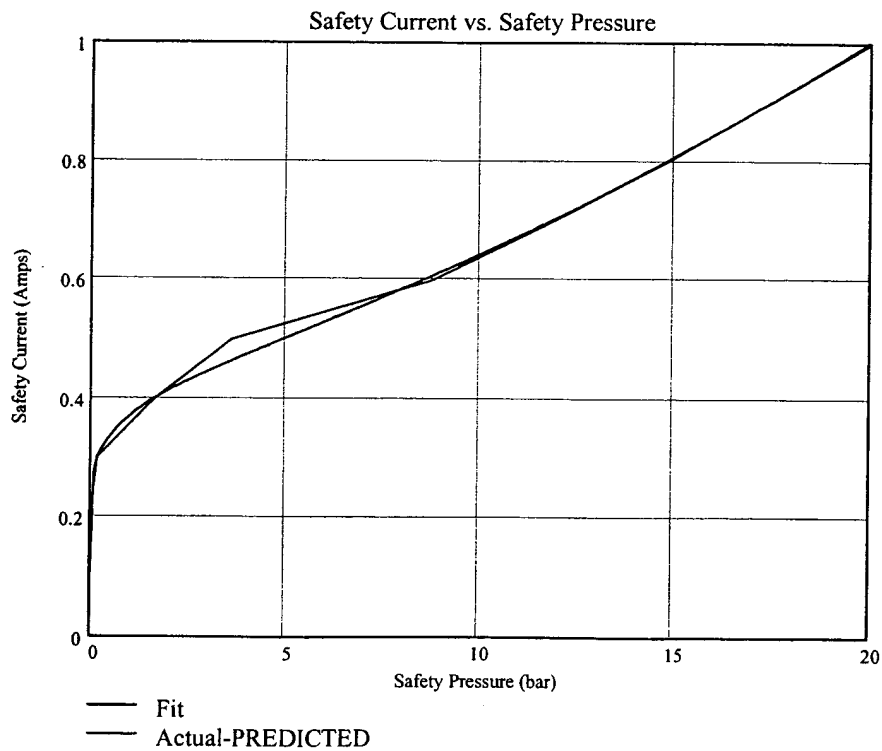
Software Calibration – Overview

□ **Electronic calibration is made possible by integrated electronics (TCU)**

□ **Electronic calibration allows**

    □ **Increased accuracy of proportional functions**

        ⊠ **Improved control**

        ⊠ **Improved fuel economy**

        ⊠ **Improved driveability**

    □ **Reduced cost**

**BorgWarner
Air/Fluid Systems**

DCS System Technology

Mechatronics Technology

Software Calibration – How it Works

Characteristic Equation Coded into Vehicle Software

$$i(P) = c1 + \frac{c2}{1+P} + c3 \cdot P + c4 \cdot P^2 + \frac{c5}{P^3 + 0.0001}$$

BW Tester Calculates Coefficients During EOL Test
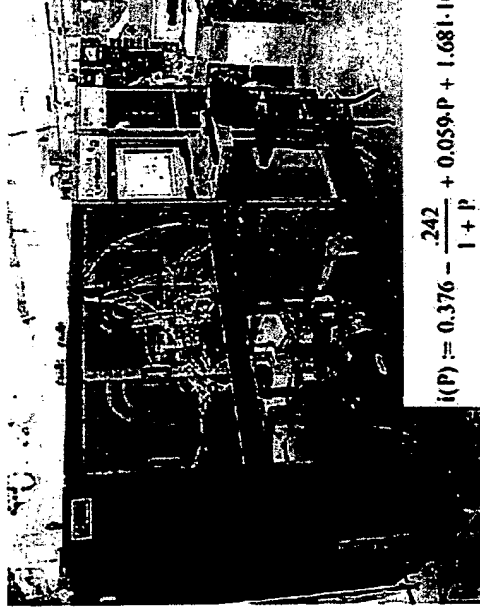
Calibration Data Written to TCU Memory during BW EOL Test

$$i(P) := 0.376 - \frac{242}{1+P} + 0.059 \cdot P + 1.681 \cdot 10^{-5} \cdot P^2 - \frac{7.328 \cdot 10^{-9}}{P^3 + 0.0001}$$

BorgWarner Air/Fluid Systems

DCS System Technology

Mechatronics Technology
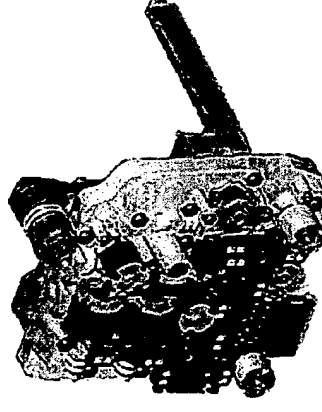
Software Calibration – What We Calibrate Electronically

Pressure Sensors (Temic)

Line Pressure Control

Lube Flow Control

Clutch Pressure Control

**BorgWarner
Air/Fluid Systems**

Confidential

Mechatronics Technology
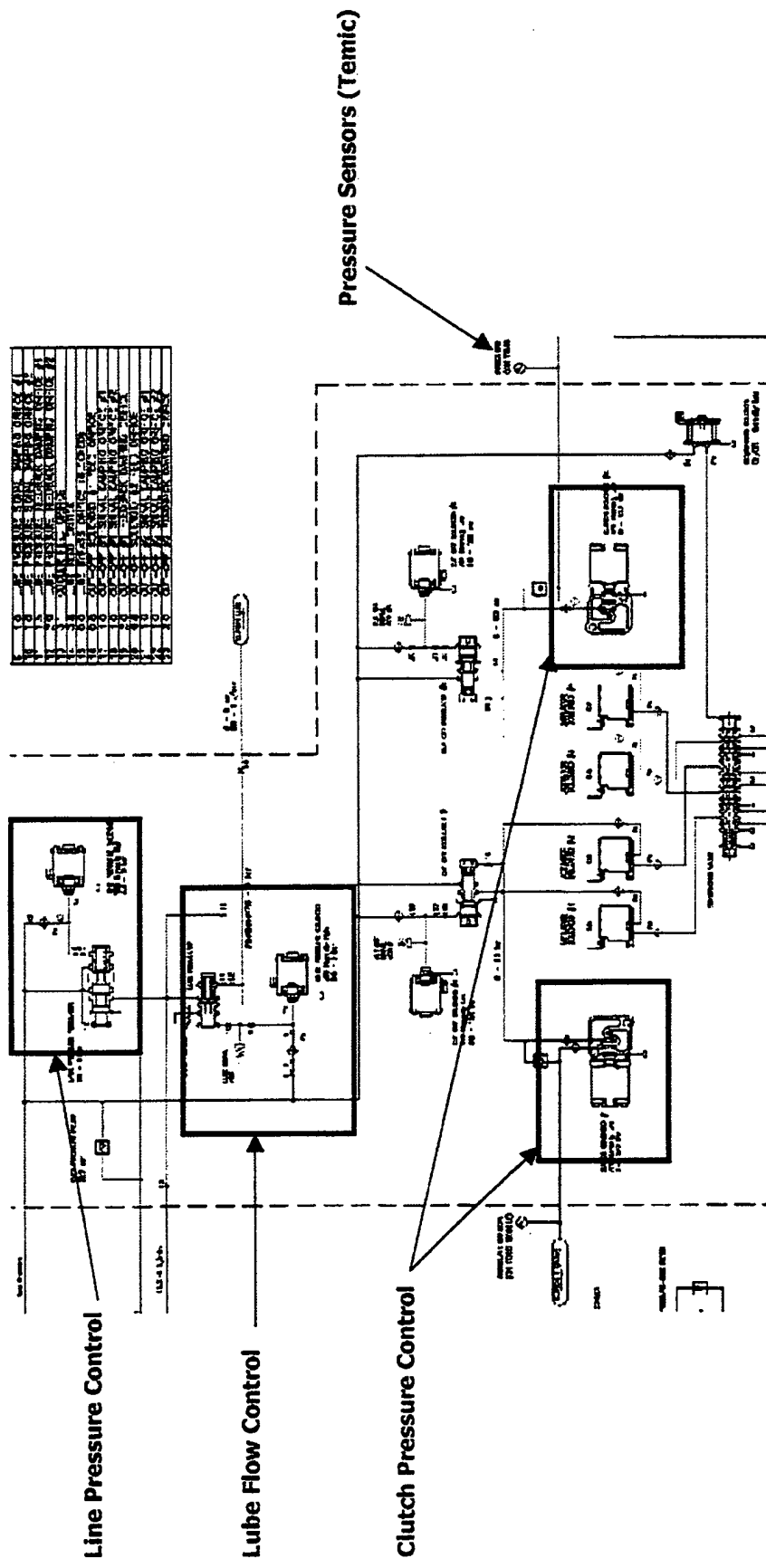
Software Calibration – Results

Characteristic Equation for Clutch Control

VW DQ 250
Clutch Control Characteristic (100 pc. Sample)

Legend:
— +/- 3 Sigma w/o Calibration
— +/- 3 Sigma w/Software Calibration

x-axis: Current (Amp) — 0.0 to 1.2
y-axis: Clutch Pressure (bar) — 0 to 15

Characteristic Equation

$$P(I) = c1 - \frac{c2}{1 - P} + c3 \cdot P + c4 \cdot P^2 + \frac{c5}{P^2 + 0.0001}$$

Sample Equation with Coefficients:

$$I(P) = 0.312 - \frac{.341}{1 - P} - 0.0501 \cdot P + 2.68 \cdot 10^{-3} \cdot P^2 - \frac{2.328 \cdot 10^{-3}}{P^2 - 0.0001}$$
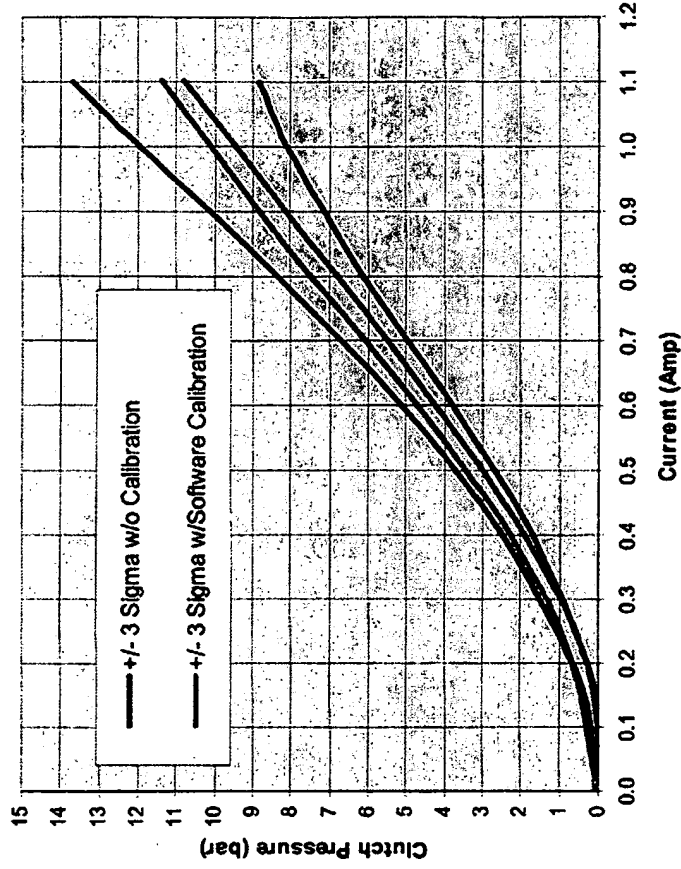
VW Clutch Pressure Calibration
E.C.Sandstrom

$data := READPRN("clutch.prn")$ $step\_data := READPRN("clutch\_step.prn")$

$i\_data := data^{\langle 0 \rangle}$ $i\_step := step\_data^{\langle 0 \rangle}$

$p\_data := data^{\langle 1 \rangle}$ $p\_step := step\_data^{\langle 1 \rangle}$

$k := 0 .. rows(data) - 1$
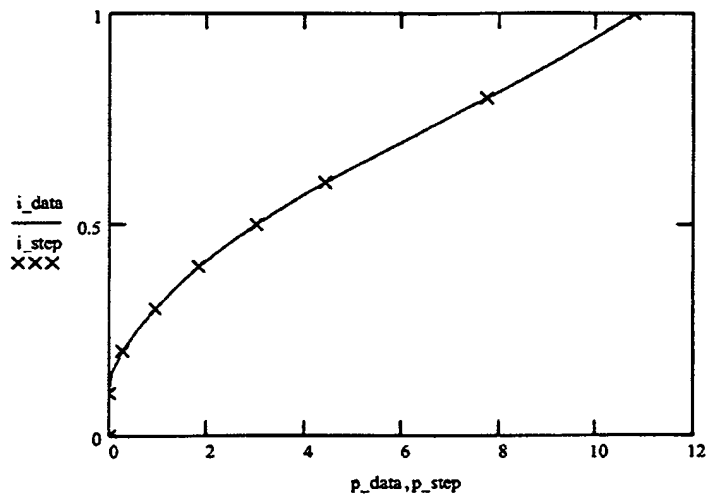
$$F(x) := \begin{pmatrix} 1 \\ \dfrac{1}{1 + x} \\ x \\ x^2 \\ \dfrac{1}{0.0001 + x^3} \end{pmatrix}$$

$n := rows(step\_data)$ $n = 9$ $i := 0 .. n - 1$

$data := csort(step\_data, 1)$

$X := \text{data}^{\langle 1 \rangle}$ $\qquad$ $Y := \text{data}^{\langle 0 \rangle}$ $\qquad$ $S := \text{linfit}(X, Y, F)$

Least-squares fitting function:

$\text{fit}(x) := F(x) \cdot S$

Sum of the squares of the residuals:

$$\sum_i \left(\text{fit}(X_i) - Y_i \right)^2 = 5.094 \times 10^{-3}$$

$\text{npoints} := 50$ $\qquad\qquad$ $j := 0 .. \text{npoints}$

$q_j := \min(X) + j \cdot \dfrac{(\max(X) - \min(X))}{\text{npoints}}$

+++   X-Y data
——   Least-squares fit
------   trace 3
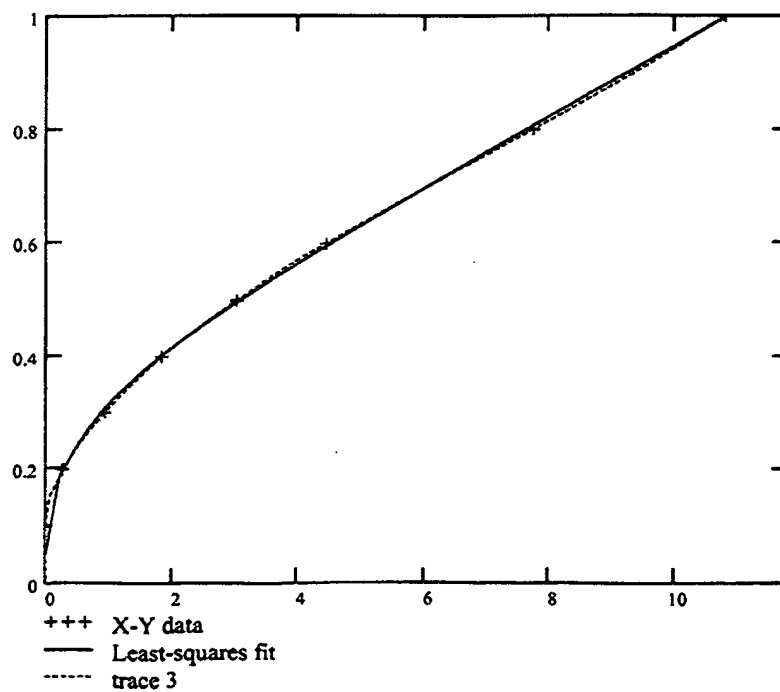
$P := 0, .1 .. 20$

EXHIBIT B

Attachments: vfs calibration coefficients_updated_12Nov02.xls.asc

vfs calibration
coefficients_u...

-----Original Message-----
From: Sandstrom, Eric (PTC-Auburn Hills)
Sent: Tuesday, January 28, 2003 9:27 AM
To: 'Braun, Johannes'
Subject: RE: VFS Data

* PGP Decrypted Message

Hello Johannes,

Attached is the most recent calibration coefficient sheet that I have released. I don't see the serial numbers you're looking for in my list. Tulle has started generating the coefficients for spare VFSs, so the list may have come from Tulle. You might try contacting Jean-Pierre Alexandre.

Regards,

Eric

-----Original Message-----
From: Braun, Johannes [mailto:Johannes.Braun@volkswagen.de]
Sent: Tuesday, January 28, 2003 8:03 AM
To: 'Sandstrom, Eric (PTC-Auburn Hills)'
Subject: AW: VFS Data

Hello Eric,
sorry, the important information (calibration data) is missing of course.
The S.N. are 02-332-001 to 02-332-023.
Attached you 'll find some (incomplete) information about our visit in Tulle (what we intend to discuss).

Regards,

Johannes

1

Von: Sandstrom, Eric (PTC-Auburn Hills)
[mailto:ESandstrom@afs.bwauto.com]
Gesendet: Dienstag, 28. Januar 2003 12:58
An: 'Braun, Johannes'
Betreff: RE: VFS Data

Hello Johannes,

Are you looking for calibration coefficients or actual performance data?

Regards,

Eric

-----Original Message-----
From: Braun, Johannes [mailto:Johannes.Braun@volkswagen.de]
Sent: Tuesday, January 28, 2003 5:12 AM
To: 'BW Sandstrom, Eric'
Subject: VFS Data

Hi Eric,

you've sent an EXCEL sheet with VFS Data R7.3. I've seen it on a sheet of paper, but no one in
Wolfsburg has the file. Can you send it once again?
Manufacturing date is 28th of november (332).

Regards,

Johannes Braun

Volkswagen AG
EAGS, Brieffach 1765/1
D-38436 Wolfsburg
Tel.: +49-5361-936489
eFax: +49-5361-957-36489
Fax: +49-5361-932577
MailTo:johannes.braun@volkswagen.de

* PGP Decrypted Message
* vfs calibration coefficients_updated_12Nov02.xls
*
*

EXHIBIT C

TestID	2076	Line Sweep		Lube Swee
Date	3/19/2003 16:36	0.0023	20.81	
Serial Number	Test D12B.001	0.2504	19.47507	
Username	SA	0.4992	15.72799	
User Comment	ps - 300 Hz driver - Run 2	0.6992	11.06831	
Temperature	91.89306641	0.7996	8.247039	
Test Duration	178.3240051	0.8495	6.806145	
Setup Number	13	0.902	5.323758	
Setup Comments	High Frequency Test	0.9489	3.849872	
Freq Mode	300	0.8994	5.217458	
Line Freq	500	0.8501	6.628895	
Clutch 1 Freq	375	0.8	8.001616	
Clutch 2 Freq	375	0.6999	10.83551	
Lube Freq	600	0.4996	15.5557	
ACC1 Freq	100	0.2497	19.36481	
ACC2 Freq	100	0.0022	20.81623	
ACC3 Freq	100			
ACC4 Freq	100			
CutOff Freq	300			
Line Dither Amp	100			
Clutch 1 Dither Am|	100			
Clutch 2 Dither Am|	100			
Passed Test	FALSE			
Resp Filename	|_Mar1903;04.39.10p.xls#			

**Clutch 1 Step / Sweep
300 Hz, 375 Hz - Run 2**

	0	0.2	0.4	0.6	0.8	1	1.2	1.4

-2

Current (Amp)

Clutch 1 Sweep		Clutch 2 Sweep		CutOff 1 Sν
0.0036	0.002369	0.0039	-0.003973	
0.1003	0.044199	0.0999	0.083053	
0.2	0.428746	0.2001	0.473744	
0.4001	1.994287	0.4004	2.11234	
0.5992	4.277582	0.5994	4.475844	
0.799	7.082444	0.7992	7.286934	
0.9997	10.04107	1.0006	10.21594	
1.3007	14.01582	1.301	14.07807	
0.9999	10.10992	1.0001	10.27965	
0.8	7.203893	0.7989	7.407373	
0.6012	4.382535	0.6007	4.558999	
0.4001	2.047143	0.4	2.16831	
0.1999	0.468471	0.2002	0.520708	
0.1001	0.080979	0.1	0.104936	
0.0034	0.001191	0.0041	-0.008686	

Clutch 2
300 Hz, 3

Step
Sweep

1.4   1.6

0   0.2   0.4   0.6   0.8

-2

Current

20	20.09797
15	15.30043
10	10.22675
4	3.997075
10	9.937565
15	15.04794
20	20.01574

Clutch 2 Step / Sweep
300 Hz, 375 Hz - Run 2
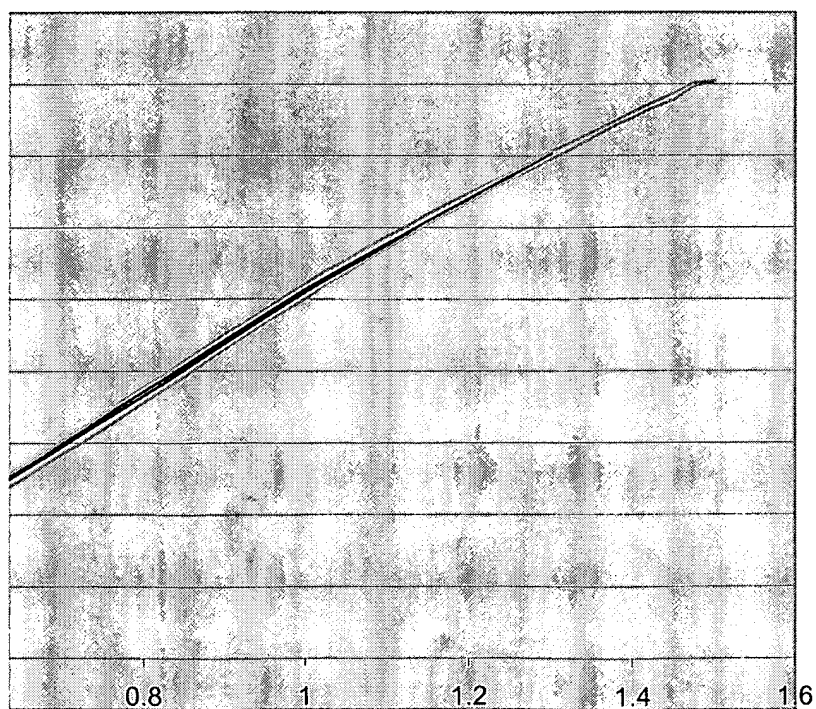
0.8   1   1.2   1.4   1.6

Current (Amp)

Clutch 1 Sweep Check		Clutch 2 Sweep Check		CutOff 1 S\
0	0.000433	0	-0.007507	
2	2.009773	2	2.038023	
5	4.834414	5	4.834553	
10	10.14594	10	10.1077	
15	14.86218	15	14.87309	
10	10.16665	10	10.12807	
5	4.910499	5	4.909206	
2	2.049836	2	2.079685	
0	-0.001418	0	-0.004983	

weep Check	CutOff 2 Sweep Check	Clutch 1 Regulation		Clutch 2 Re
		20.81	0.010786	20.81
		19.47507	0.008092	19.47507
		15.72799	0.002033	15.72799
		11.06831	-0.005458	11.06831
		8.247039	-0.009245	8.247039
		6.806145	-0.003859	6.806145
		5.323758	-0.004196	5.323758
		3.849872	0.00178	3.849872
		5.217458	-0.012275	5.217458
		6.628895	-0.006552	6.628895
		8.001616	0.002453	8.001616
		10.83551	-0.007983	10.83551
		15.5557	0.005147	15.5557
		19.36481	-0.002428	19.36481
		20.81623	-0.001334	20.81623

egulation	Line Cals		Lube Cals		Clutch1 Ca
0.006548	1	1.051697	1	5.88E-39	1
0.005622	2	-0.025081	2	5.88E-39	2
-0.005235	3	-0.000667	3	5.88E-39	3
-0.009275	4	-2.19E-10	4	5.88E-39	4
-0.006413					5
-0.012305					
-0.011716					
-0.000858					
-0.010706					
0.003266					
-0.007928					
-0.012305					
0.006043					
-0.007592					
-0.006666					

ıls	Clutch 2 Cals		CutOff 1 Cals		CutOff 2 Ca
0.358215	1	0.374329	1	11225656	1
-0.258041	2	-0.300522	2	65537	2
0.063557	3	0.057354	3	66974	3
0.000333	4	0.000689	4	262218	4
-9.48E-06	5	-6.71E-06	5	131334	5

als		Line Pressure Regulation		Line Repsonse	Lube Resp
	262	15.58951	20.01574		
	258				
	773				
	1030				
	0				

onse   Clutch 1 Response   Clutch 2 Response   ACC 1 Res

sponse 1   ACC 1 Response 2   ACC 2 Response 2   ACC 3 Res

g Response 2 (Port 1)   CutOff 1 Response   CutOff 2 Response   Leakage

Sequencing Response 1 (Port 5)	Sequencing Response 2 (Port 5)	Valve Body
		0
		1
		2
		3
		4
		5
		6
		7
		8
		9
		10
		11
		12
		13
		14
		15
		16
		17
		18
		19

/ Info	Supply Pressures		Line Sweep Check Currents		Lube Swee
19000	0	21.13311	20	0.1776	
1	1	20.00236	15	0.5244	
1438	25	20.17818	10	0.7351	
74	5	19.15222	4	0.9405	
0	3	20.70639	10	0.7342	
6	26	9.867792	15	0.5241	
1	7	22.08644	20	0.1775	
6	27	19.98006			
1	31	20.11421			
2	29	20.6713			
1	33	22.1488			
5					
3					
6					
4					
171					
1					
1					
4					
2					

ep Check Currrents		Clutch 1 Sweep Check Currents		Clutch 2 Sweep Check Currents		Line Increm
		0	0.0046	0	0.0066	0.0026
		2	0.401	2	0.3918	0.0249
		5	0.6414	5	0.6283	0.0502
		10	1.0032	10	0.9889	0.075
		15	1.3734	15	1.3705	0.0999
		10	1.0063	10	0.9903	0.1249
		5	0.6423	5	0.6281	0.1501
		2	0.401	2	0.392	0.1749
		0	0.0043	0	0.0063	0.2002
						0.2262
						0.2498
						0.2748
						0.3004
						0.3245
						0.35
						0.3752
						0.3998
						0.4247
						0.4493
						0.4739
						0.4996
						0.5249
						0.5505
						0.5748
						0.5993
						0.6244
						0.6506
						0.6772
						0.701
						0.7227
						0.7494
						0.7741
						0.8009
						0.8231
						0.8496
						0.8739
						0.9005
						0.9245
						0.9498
						0.9738
						1.0007
						1.0237
						1.0484
						1.0758
						1.0998
						1.1257
						1.1507
						1.1746
						1.1994
						1.2003
						1.175

1.1481
1.1254
1.1002
1.0747
1.0503
1.0243
1.0001
0.974
0.9503
0.9245
0.9008
0.8741
0.8513
0.8247
0.8
0.7749
0.7503
0.7256
0.6998
0.6755
0.6501
0.6258
0.599
0.5744
0.5487
0.5251
0.4999
0.4752
0.45
0.4242
0.4001
0.3754
0.3502
0.3253
0.3
0.2735
0.2504
0.225
0.2001
0.1751
0.1501
0.1251
0.1001
0.0749
0.05
0.0251
0.0024

nented Step	Lube Incremented Step	Clutch 1 Incremented Step		Clutch 2 Inc
20.75925		0.0033	0.005147	0.0039
20.73198		0.0249	-0.001502	0.0248
20.67416		0.0499	0.002453	0.0501
20.60026		0.0752	0.010701	0.0752
20.50305		0.1001	0.044536	0.1001
20.35846		0.1249	0.118011	0.1249
20.23533		0.1501	0.199819	0.1501
20.08762		0.175	0.297029	0.1748
19.9038		0.1995	0.407621	0.1998
19.68969		0.2251	0.549101	0.2253
19.46127		0.2502	0.680482	0.2502
19.20229		0.2745	0.84477	0.2746
18.95249		0.2999	1.022273	0.3001
18.66516		0.325	1.210044	0.3249
18.32959		0.3488	1.418266	0.3495
17.97728		0.3742	1.633896	0.3745
17.58617		0.3999	1.872333	0.3998
17.17848		0.4242	2.111949	0.4243
16.79427		0.4487	2.366967	0.4493
16.34786		0.4749	2.628129	0.4749
15.88016		0.4991	2.910332	0.4988
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